SCIENTIFIC KNOWLEDGE AND TECHNOLOGICAL KNOWLEDGE: IDENTIFICATION OF RELATIONS BASED ON PEDAGOGICAL ACTIVITIES WITH EDUCATIONAL ROBOTICS

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Abstract
The recent advent of free platforms which allow the creation of educational robotics projects, has brought new possibilities for education, even if doubts remain about methodologies and the learning achieved in pedagogical processes mediated by new digital technologies. Anyway, educational robotics projects are already part of the curriculum in many private schools, and begin to be present in public schools as well. If doubts remain about the relationship between content and technology, it is possible that technological education will be approached in a fragmented way and oriented to a pragmatism that would assume as valid only the applicable scientific knowledge. If this occurs, it is also possible for graduates of higher education courses to remain limited to the use and to the implementation of technologies rather than being oriented to protagonism attitudes face the need for innovation. Thus, this research turned to a verification about the stage of knowledge of teachers in Elementary Education level regarding to the relationship between scientific knowledge and technological knowledge. It is important the understanding that there is a relationship between science and technology, and consequently between school science content and current technologies, which goes against statements that content studied at the school are unrelated to the technological world in which children and adolescents are immersed. The research also investigated what is present in the various types of educational robotics dissemination material, including open access documents, technical manuals, scientific articles, academic dissertations and theses, official Brazilian educational documents, as well as the documentation of the Brazilian Olympiad of Robotics, because these materials will be taken as basis by teachers interested in using educational robotics in their pedagogical approaches. In addition, training activities were conducted with teachers of Elementary Education regarding the pedagogical perspectives of educational robotics, with answers to a thirty statements questionnaire about the subject. It is possible to conclude that teachers not only recognize the relationship between their areas of knowledge and the creation of technologies but also recognize that the contents addressed by them contribute to the formation of individuals with the capacity to create new technological products. However, activities related to this research also showed that they know superficially or are not aware of such advances and consequently the ways of transposing the resulting complexities to curricular contents. Those teachers, who demonstrate maturity in relation to democratic perspectives of technological constructions, also present substantivist understandings about technology recognizing it as neutral and as an application of science. The materials that constituted the documental corpus of the research were methodologically studied under the light of Discursive Textual Analysis, from which emerged categories indicating that current activities with educational robotics do not harmonize the complexities involved, while at the same time show pragmatists preferences. In order to reach these conclusions, current technologies and scientific advances were taken into account as well as studies in the field of Philosophy of Technology, having also epistemological support in the rationality and conception of science of Gaston Bachelard.

Keywords: Educational Robotics, Interdisciplinarity, Scientific and Technological Education, Arduino, Computer Programming, Philosophy of Technology, Artificial Intelligence.

1 INTRODUCTION
At the present moment, in which we live a preparation for what has already been called the fourth industrial revolution, concepts, amongst others, such as hybrid intelligence, are emerging: humans and machines working and thinking together, representing a rupture of the current paradigm and causing a direct impact into the future of jobs. We ought to understand that in order to be able to participate in this context, the only possible way is that of a good quality Elementary Education. At the heart of this fourth industrial revolution, there are computer concepts that have already been implemented and have become increasingly popular, such as the Internet of Things. If previously we
The internet that transformed the way in which humans communicate, now it is time for things to communicate as well. The hybridism that now emerges is already being called the Internet of Everything.

There is no way to predict, at least precisely, what will be possible to be created from this perspective. In order to prepare the schools to be able to follow this path, and constituting itself as one of the central objects of our study, there are the technologies of electronic prototyping and teaching of computer programming, currently quite adequate financially and cognitively to those who compose the Brazilian Elementary Education.

The ideas proposed here, which were constructed as a result of the investigative hypothesis stating that Brazilian Elementary Education teachers recognize the disconnection between current technological advances and school scientific knowledge, understanding science and technology as neutral, guide themselves, primarily, in defense of the search for scientific and technological knowledge in pedagogical activities with educational robotics, in detriment of practices only directed to applications of robotic artifacts, that is, against essentially pragmatic attitudes in these pedagogical approaches.

For this purpose, we sought contributions from the Philosophy of Science, specifically from Gaston Bachelard’s work and his conception of science, in order to find a reconstruction of the understanding of science and the relations between science and technology. The contributions of the Philosophy of Science were added to the contributions of the Philosophy of Technology, with respect to ethical and social problems, at least those that we are already familiar with, and which will always be imbricated to the scientific and technological development, in defense of the indissociability among Science, Technology, Society, and the technological and scientific advances. In agreement that this path to the future must go through school, we understand that such questions need to be raised with those who will be responsible for conducting these processes: Elementary Education teachers.

One of the key defenses of this study, considering the pedagogical scope, is the search for knowledge, particularly for a scientific knowledge based on a technical rationality indissociable from its experimental results, unveiling an existing technological pragmatism in the pedagogical process. The historical contributions are understood here as antidotes in defense of a conception of science different from the one in which common sense prevails, which perhaps contributes to the development of the necessary skills that allow to achieve attitudes of protagonism together with the processes of technological creation and innovation. If until recently innovation was much more dependent on the social and market demands, it is necessary to realize that now innovation finds other spaces, being demanded also by needs originating from their own technological creations, recursively.

Lévy [1] in approaching the development of the new communication tools, refer to them as thrusters of a far-reaching mutation, which makes us to turn back into nomads. According to him, to move is no longer to move from one point to another on the surface of the earth, but to cross universes of problems, lived worlds, landscapes of the senses, and even if we did not move, the world would change around us, and that movement demands from us a rational adaptation. And he questions: “But how to know that an answer is appropriate to a configuration that presents itself for the first time and that no one has programmed?” [1]. This "rational adaptation" seems to have an evolutionary origin. We tend to lean uncritically on technologies so that we do not become extinct. We tend to lean to new technological resources as if the school were not the appropriated space to understand them. Hence, it would be understandable that this loss of reference should have repercussions in teaching.

Thus, based on the hypothesis investigated here that the Brazilian Elementary Education teacher recognizes the disconnection between current technological advances and school scientific knowledge, it is understood that this disconnection could promote a pedagogical approach with technologies that would result in a pragmatic understanding of the school scientific knowledge, establishing itself as an obstacle to protagonism. We must, beforehand, understand our own conception of technology and later immerse ourselves in the history of science, from which we can use an epistemological perspective that may favor a better understanding of these questions. It is a destructive, inverse movement which starts from the seduction, submission, enchantment and, as we have seen, a need to adapt to technology, returning to the origins of pre-scientific knowledge in the Bachelardian sense. We investigated here if this understanding of technology in the context of the teaching of Brazilian Elementary Education is aligned with the modern common sense, that is, if the teachers involved with scientific education still conceive technology in a neutral and autonomous way.

Digressions focused on the understanding of technology in their ethical, economic and social contexts, support works by authors of the Philosophy of Technology [2], [3], [4], and it can be concluded from
them that it is necessary, in some way, to initiate critical engagement in these debates [5], [6]. Although one can understand that effective democratic changes demand new policies at the governmental level and, before that, new political conceptions, we tend here not to underestimate an awareness that starts at school. Even being a complex subject, it is necessary to face it and get involved with it, and it is understood here that the opportunity is latent at this moment in which we can, from an early age, put children and adolescents in educational processes of technological creation, integrating to the constructive pedagogical activities variables that take into account the relationship between technology and human nature.

It is also important to emphasize that, in regard to technological knowledge, the economic interests that guide it are always present in the discourses, but questions about the unpredictability inherent in some technologies are absent or difficult to verify, such as in the case of informatics and social networks. In these cases, the scope and possibilities of these technological creations were never accurately predicted, which would allow questions to be raised as to whether or not the technological products are always oriented by economic interests and aimed for maintaining power relations among human beings. The consequences of technological development are not always foreseen or conceived a priori by the dominant power. This control would be done a posteriori, whenever becomes possible to measure advantages.

It is our concern here the way in which teachers understand the relationships between the scientific knowledge they approach and the use of such pedagogical technologies. It is understood that there may be difficulty in establishing such relations or exist a certain pragmatical induction, once the implementation of an electronic artifact in the form of a prototype can be understood by the student as a practical example of why to achieve scientific knowledge, which is much broader and abstract than only limited and practical (or concrete). Such conceptual complexity finds support in Gaston Bachelard's thinking and conception of science. His conceptions and theoretical categories allow teachers to face these challenges in a safe manner. Lopes [7] states that Bachelard pointed out, in an unsystematic way, to the question of teaching, and his pedagogical concern is explicit when he states that he considers himself more teacher than philosopher. In Bachelard [8] we can identify a vision that is essentially concerned with scientific education, raising epistemological questions about the attitude of teachers and learners towards knowledge, as well as being concerned with the social, collaborative and critical character of education.

Bachelard, who devoted himself profoundly to the studies of Physics, Chemistry and Mathematics, also showed in his work the interdisciplinary character of scientific knowledge, constituting it as an epistemological discourse beyond its time, making it adequate to give support to an up to date scientific education that is open to the integration of new resources. Therefore, the interdisciplinary and pedagogical characteristics present in Bachelard's historical epistemology, already constitute, in part, reasonable justifications for their choice as a theoretical basis to support the pedagogical and scientific nature of this research. However, if we must recognize the importance of pedagogical praxis and if this recognition echoes Bachelard's discourse, it is pertinent to argue that during the teaching activity, people must also be in tune with his conception of science.

We can begin with the analysis of Bachelard's critique of empiricism. Empiricism is naturally an opinion-maker, and in constructing his view of science, Bachelard [8] strongly criticizes opinion by understanding it as a translation of needs in knowledge. He explains that "in scientific life problems are not formulated spontaneous. It is precisely this orientation of the problem that characterizes the true scientific spirit. To the scientific spirit, all knowledge is an answer to a question. If there is no question, there can be no scientific knowledge. Nothing is evident. Nothing is free. Everything is built" [8]. The scientific construction that Bachelard refers to already points to a view of science that does not describe the phenomena, but produces its own phenomena, with mediating instruments built by a double instrumental and theoretical process [9]. Hence the characterization of science as a human enterprise. Perceiving nature as being at the disposal of science to arrive at an absolute knowledge denotes a dogmatic interpretation. The instrumental mediation for the production of phenomena of science gives rise to a bachelardian category that received from the author the name of phenomenotechnics. In Bachelard [8], [10], [11] several passages explain the emergence of a phenomenotechnics as a technique to act scientifically in the world, beyond the visually constructed conceptual limitations, and with a view to promoting the existence of phenomena not from nature itself. He understands that science builds its objects. That it never finds them ready. The phenomenotechnics prolongs the phenomenology. A concept becomes scientific in the proportion in which it becomes technical, in which it is accompanied by a technique of attainment [8].
Beyond the conceptualization of an instrument as something visible and palpable, Bachelard explains that, in the production of scientific phenomena, and based on the crystals found in nature, although they have very regular external forms, they rarely have the intimate regularity desirable. Processes that aim to obtain an ideal crystal produce a material endowed with geometric characteristics, having, from then on, a materialized geometry. According to him, a crystal created in the laboratory is no longer an object, it is an instrument. An apparatus in which an operation is performed. It is still constant, in Bachelard's work, the defense of a search for the abstract, characterizing our senses and our first impressions of them as real obstacles to overcome in the way of scientific knowledge. If it is science that produces its own phenomena mediated by technique, should one not think in a similar way in science education?

We understand that the construction of educational robotic prototypes should focus much more on the scientific content in which they are based than in the application of those artifacts. It is of great relevance to create a pedagogically produced scientific instrument that can detect, for example, variations in the concentration of air gases. But the space of opportunities for deepening scientific knowledge in each of these creations is broad, and must be explored. Focusing only on the instrument as the final product of pedagogical activity can make learning somewhat pragmatic, superficial and too much fragmented, which in turn can facilitate the overlapping of a harmful realism to the detriment of a rationalism that makes it possible to understand pedagogically the production of phenomena and not merely reproducing or describing them. A key role of teacher mediation emerges here, which is put between the needs for change in pedagogical practices - being established almost in the form of a student's right to build his knowledge aided by technological instruments - and the epistemological obstacles raised by Bachelard with relation to the declared, non-critical and merely empirical sensualism of the first experiences. This mediating role will, therefore, have a posture of resistance to symbolism, always seeking to highlight the observer of its object, defending the student of the mass of affectivity that focuses on certain phenomena quickly symbolized and, in some way, very interesting [8].

The appreciation of openings for abstract thought, so present in the Bachelardian discourse, becomes stronger with the inherent needs of pedagogical activities with new technologies. So we can ask ourselves how students act in relation to the learning processes of computing, since they need to use abstractions (programming language) to construct abstractions (algorithmic structures). The few academic papers related to science education involving the construction of programmable electronic prototypes usually do not touch the programming aspect. They either assume that other teachers already know, or will not have difficulty in learning it. To consider educational robotics as a possibility of construction of scientific instruments for theoretical insights allows the teacher to make a balancing of the complexities. Not necessarily are present in all robotic projects of educational scope the four complexities of robotic pedagogical projects, such as: programming, communication, mechanics and electronics. The teachers should not be limited to their impressions that educational robotics only consists of prototypes directed to the robot-building market. It is verified the need to use such platforms to foster, with equal importance and in a creative way, the search for scientific knowledge by building technological teaching tools.

The theoretical basis of Bachelard's thinking allows us to understand a path to be followed in terms of learning focused on protagonism, since in explaining how science produces and organizes its own phenomena, by using appropriate instruments, it inspires pedagogical praxis with technologies. Teacher must keep in mind that, as Bachelard explains, no experimental result must be stated in an absolute way, separating it from the various experiences that have enabled it to be obtained. If it is science that produces its own phenomena mediated by technique, should one not think in a similar way in science education? If we agree with that, we can defend that the pedagogical praxis with educational robotics, which is the focus of our studies, be recognized and focused on the creation of technological artifacts in the form of instruments oriented to conceptual insights, confirmations and refutations of hypotheses. Should we aim for the professional sphere merely to use the technologies or to be part of their constructions? This would be of relevant understanding, since theories, rational thinking, abstractions and complexities are part of the core of current and future technological constructions. It will not be a mere enchantment by the symbolism of the pedagogical activities with robots that will be able to change our condition of consumers of technologies to protagonists of scientific and technological advances.
2 METHODOLOGY

There were two main sources of analysis that constituted the documentary corpus of this research: a questionnaire with 30 statements with degrees of agreement in relation to philosophical and pedagogical issues involving science, technology and educational robotics, as well as documents referring to the same theme found through searching on the internet. The documentary sources used were:

- Articles and academic papers published between 2015 and 2017 in the research databases Redalyc, Scielo, Bank of theses and dissertations of CAPES, ERIC, and Google Scholar, in Spanish, Portuguese and English. The research filter used, because of the free license to use and the expressive growth of the Arduino electronic prototyping platform, was only "arduino", and only documents of free access and pedagogical approach were selected.

- Technical-pedagogical manuals of Brazilian companies that sell educational robotic kits included in the editions of the Educational Technologies Guide of the Brazilian Ministry of Education.

- Official Brazilian documents such as the National Curricular Common Base, Educational Technologies Guides of the Brazilian Ministry of Education and the National Curricular Guidelines for Elementary Education.

- All free access documents of the Brazilian Robotics Olympics, available on its website, including all theoretical tests produced between 2007 and 2016.

- Text tutorials and video tutorials available on the internet by searching the Google tool as a filter using "Arduino tutorial" by choosing only documents between 2015 and 2017, limited to free access documents and of educational nature. We selected the first 50 text tutorials and the first 50 video tutorials that fit the given criteria.

There were 349 documents analyzed using the methodology of Discursive Textual Analysis – DTA [12], joining them the questionnaires answered by teachers, also submitted to the steps of the DTA analysis cycle, with a view to establishing new understandings on the subject. All 42 teachers participating in the research carried out a 20-hour training course on the pedagogical perspectives of educational robotics, in which experiments using the Arduino board were assembled taking into account the possibilities of curricular integration of the knowledge demands intrinsic to the processes of construction of instrumental and robotic prototypes. All teachers answered the survey questionnaire before the training course started. Still, it is important to mention that there was no imposition for this or that teacher to be part of the training course, which was free of cost.

Thus, the analysis of the documentary corpus was carried out with a careful beginning of the process of deconstruction of the texts in the search for units of analysis, relating them in a way oriented to the constitution of categories whose relations gave origin to a metatext. Such categories were pre-classified by a phenomenological bias and raised, more propitiously, under a pedagogical bias. In the analysis of the corpus, with a view to the constitution of units of analysis, the statements and explanations of the authors about the usefulness and the implementation of robotics were identified, whether in the cognitive and pedagogical approach or in the social or philosophical approach. It is understood by cognitive and pedagogical everything that refers to the aspects aligned to constructions of knowledge, including technical aspects and learning methodologies. As by social or philosophical, it is understood as relating to ideological and ethical issues, as well as with respect to the impact of the presence of robots and new intelligent technologies in the society and that will have repercussion in the quality of life of the people and in the future of jobs.

Under this inclination, it was not a focus of analysis, that is, it was not part of the criterion of unitarization, everything that relates to the theoretical basis used by the author of the document belonging to the corpus. In other words, if there were theories in which an author found support, produced an academic article, a tutorial, a manual, a dissertation, etc., they are not conclusions, quotations or references of his/her theoretical foundations analyzed by this research with a view to unitarization, but rather, we focused on the explicit understandings of the authors of the texts of the corpus, the understandings written or stated in a pulverized manner by the different types of material that compose the documentary corpus. Thus, an additional inductive and prospective approach was developed in preparation for the next stage of categorization.

Regarding the categorization stage, and aware that the DTA methodology focuses on the renewed comprehension of the whole, it is natural that new categories arise from the process of unitarization.
Two groups of categories were generated. At the first level, which we can call sub-categories, they were constructed and identified according to a phenomenological domain of robotics as a broader theme, involving pedagogical, technological, scientific, economic, social, professional, ethical, philosophical, cognitive and pragmatic as presented in the analysis of the documentary corpus. The final categorization criteria, which grouped the sub-categories, were aligned with the main focus of the research in the form of a critical reconstruction of the investigated phenomenon, anchoring itself in the pedagogical spheres of the work of constructing educational robotic artifacts.

The final emerging categories were:

- restrictive intradisciplinarity
- cognitive scalability
- abstraction and mathematization
- artificial intelligence
- pragmatism

The main structuring points of each one of them already constitute results obtained, and will be, therefore, together with quantitative analyzes originated from the answers to the questionnaire, briefly exposed in the following section of this article.

3 RESULTS

The data show that the participants recognize the student’s fascination by the technologies, as well as they demonstrate their interest in making use of educational robotics for the learning of school subjects. The exposure of the work related to this research, in the form of training courses on educational robotics, has, to a certain extent, led to these responses of agreement, since invitations were made to teachers without any kind of compulsion, determining a probable adhesion only of those who might have some interest or curiosity about the subject. Autonomous conceptions of science and technology still prevail among the participants, since science would advance, according to the concordances, from the exploration of the world in which we live, and technology, arising from the advances of science, would impose on human beings an adaptation to it.

There is a slight tendency of participants to consider educational robotics as something more associated with their conceptions of technology when compared to other educational technologies such as presentation softwares, internet, spreadsheets and applications, and there is also recognition of a concept about technology disconnected from economic interests and power relations. About 1/3 of the participants understand that weapons are not neutral technology tools. This is also evidenced, even if timidly, in the recognition that technology should not necessarily turn to the satisfaction of human needs. Still in relation to the importance of the debate and the presence of philosophical studies in processes that involve educational technologies, it is verified that the participants do not see the technological development as exclusive and restricted to scientists, even with the supposed claim that they - technologies - can be dangerous. The same is true for external aspects to the technical sphere since the participants understand that issues related to the social impacts of technology should not only be addressed by people related to the areas of human and social sciences by a supposed, as stated in the affirmative, better experience in the area.

They present divided opinions regarding the need to be a work with educational robotics aimed at the creation of something connected to the needs of the people instead of directed to the learning of some scientific concept or of some content being approached. They also agree that there is a relationship between their areas of knowledge and the creation of electronic technologies, as well as they agree that the contents addressed by them in their teaching activities contribute to the training of individuals with the capacity to create new technological products.

Regarding the category of constructed Restrictive Intradisciplinarity, it can be seen that the activities of Educational Robotics have difficulty to develop as interdisciplinary works, manifesting more intradisciplinarily in the form of relatively complex works that end up demanding knowledge generally centered in the areas of Mathematics and Physics. Many of the content on which robotics depends are merely being tangential, what can promote a pragmatist understanding preventing some professional opportunities such as in the fields of research and development of new materials.

With regard to the category of Cognitive Scalability, it is advocated here that electronic prototyping platforms such as Arduino are scalable, posing adequate freedom for different pedagogical
approaches to be executed at different levels of complexity. However, are present in the documents reports that show the accomplishment of projects of educational robotics that do not take this into account. In these cases, there may be an imbalance between the desired objectives and the students' cognitive level, often as a result of pragmatist pedagogical guidelines with the potential to divide students between those who like and those who do not like technology and robotics.

Regarding the category of Abstraction and Mathematization, it is evident in reports of experiences that there is a slight inclination to give preference for experimentation, with very rare acknowledgments about the importance of mathematization and the rationalization of phenomena. If on the one hand the overvaluation of experience makes sense, as the access to educational technologies has never been so easy, on the other hand, this overvaluation cannot end up resulting in empiricist pedagogical approaches.

There is a clear investigative need regarding appropriate pedagogical forms to approach Artificial Intelligence in Brazilian Elementary Education. First, even if this subject is increasingly present in the media and our daily life, it is practically not present in the documents consulted, and second because there is no knowledge of how the curricular contents relate to the theme. The processes that intend to deal with this subject must respect prerequisites such as knowledge of programming logics and data structures, topics that are distant or still very incipient in Brazilian public schools.

Finally, in relation to the category entitled Pragmatism, constructed from social, philosophical, environmental, ethical and human questions, it is verified that these questions are merely referred, at the most, and no activity has been found that dealt with these themes with depth.

4 CONCLUSIONS

It was observed, in this investigation, that the participating teachers not only recognize the relations of their areas of knowledge with the creation of technologies, but also recognize that the content addressed by them contributes to the formation of individuals with the capacity to create new technological products. They feel also able to exemplify how the creation of technologies like tablet computers, smartphones, internet, artificial intelligence, robots and games, is dependent on the content addressed by them in their teaching activities.

This potential to form individuals endowed with a supposed technological protagonism can be questioned when the recent research and developments in science and technology are approximated to teachers, including the philosophical questions inherent to these progresses. These approximations were carried out in the training courses in educational robotics constituent of the work of this research, and evidenced that they know superficially or are not aware of such advances and, consequently, the ways to transpose the complexities resulting from them to curricular contents.

Regarding the understanding of the teachers concerning robotic artifacts in pedagogical terms, the educational robotics doesn’t have a supposed obligation to be focused on something connected to the needs of the people, and it is also seen with the potential to promote the learning of some content being addressed. On the other hand, the lack of knowledge at a certain level of what could be the technology-mediated education makes the same teachers understand that the creation of a functional robotic prototype is a complete way of evaluating the student, after all, according to the understanding of the teachers, the student was able to put into practice knowledge that he/she learned. The same teacher who, in majority, disagrees that the time dedicated to learning should be optimized by focusing science teaching only to the results of the scientific achievements, and not to the processes that led to these results, does not find support for this important and salutary understanding since the relations between scientific progress and robotics are not evident in documents on the subject, even they have a professional or pedagogical inclination.

The complexity of the subjects and the overlapping of scientific and technological activities lead teachers to show maturity in some aspects and lack of knowledge in others. They already understand that the directions that technology must take, must have a democratic foundation, disagreeing that only scientists should have the power to decide on the development of technologies. Similarly, they demonstrate consistency in understanding that questions about the social impacts of technology must be addressed by teachers of any area of knowledge, and should not be tied primarily to studies in human and social sciences. The participants of this research understand as being necessary to adapt to science that, on its own, would advance from the exploration of the world where we live. They agree in the same proportion that we must adapt to technology as it progresses from the advances of science, understanding technology as only the applied science.
Trends in accepting neutrality are evidenced by the interpretation of proportionately larger concordances with claims that weapons are neutral technological tools and can be used for good and bad things. They also accept that errors can occur as a result of technological advances, understanding them as inevitable and acceptable when in favor of a supposed advancements of humanity. In more easily understood examples involving the daily use of technologies, participants also expose their acknowledgments that technology may be autonomous, because when it is stated that the frequent need to replace technological artifacts such as computers and smartphones is normal, since this substitution is supposed to occur due to the rapid technological evolution, the great majority agrees with the affirmation, apparently not taking into account economic issues and business strategies involved that indirectly reduce social and cultural aspects and mere externalities.

Still in relation to what is technology education, and corroborating previous interpretations about the levels of understanding on the matter, participants largely agree that both students who create robots and students who create slide presentations, access the internet, assemble electronic spreadsheets and computer applications, are learning technology. This view, which dissociates technology from all its philosophical complexity, is consistent with expressive agreement with assertions that science and technology must be efficient and problem solving oriented. Pragmatism is unveiled to the extent that, including both technological education and scientific education, according to the understanding of the participants, should also be equally focused on efficiency and problem solving.

Pedagogical approaches with educational robotics based on the types of materials that were the object of study of this work, will tend to be influenced by the same characteristics that led to the composition of the presented system of categories. The conclusions being made here should be understood as reflective digressions constituent of the vigilant and pondered behaviors mentioned previously, and which are being proposed here for the pedagogical conducts. Educational robotics, despite its interdisciplinary nature, ends up presenting itself in a more inclined way to the areas of Physics and Mathematics, while at the same time expressing dependence on basic knowledge of these two areas. In other words, even if robotics depended only on Physics and Mathematics, there are evident demands and deficiencies for basic knowledge of these two areas so that there can be an adequate understanding of the relations between scientific knowledge and technological development. As if that were not enough, the sometimes present utilitarian vision ends up overlapping the new approaches that would allow harmonizing advances in the conceptual demands of electronics, mechanics, programming, and data communication generally involved in robotic constructions.

Teachers, in turn, will need to critically consider the positive features of the available documentation. They will find in the academic documents (articles, theses, dissertations) the forms of approaches more aligned with what is being proposed here. Such approaches are focused on the construction of instruments for learning, using technological mediation with levels of depth that allow to harmonize the complexities involved, in a scalable way. These academic materials, even if presented as those that best transpose technical and theoretical complexities, are still a little distant from what has been produced and disseminated worldwide in relation to advanced topics in science and technology. It would be up to teachers to cover this gap through access to national and international scientific journals.

If theoretical knowledge and laws of Physics can be put into practice with educational robotics, it should not be understood that preference should be given to experimentation in order to undervalue the theory, since the controls and organization of these natural phenomena end up being governed by abstract computational and mathematical structures. It should be understood that processes and behaviors can be represented in an algorithmic way, aiming to create simulations and abstract models understood in the light of programming structures and Mathematics. It is not, therefore, a question of making computational thinking impose a deterministic behavior on human beings. Artificial intelligence drew attention by being present in the references and by being explicitly distant from the experiments performed. Due to the intense relationship it has with robotics, it will be necessary to study ways of approaching it in Elementary Education, starting with the valorization of Mathematics, Statistics, computational thinking and abstract knowledge.

A systematic view of the constructed categories and subcategories leads to the conclusion that a pragmatist character is prevailing in pedagogical activities and in the documents that approach educational robotics. At the same time as this short-term pragmatic view is concerned with developing students' skills that are important and necessary for professional exercises and also preparing people for the job market, it is restrictive in limiting the horizon of opportunities to occupations much more focused on the use and application of ready-made technologies. It would be better to expand the range of career opportunities by including those that involve research and scientific and technological
innovations, and in addition, can be developed in an inseparable way from social, ethical and human concerns.

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